

ment is that the lakes which were so formed appear now, after many centuries, to be in the process of transferring themselves once again to their old place, the place which was assigned to them in early Chinese maps.

It is characteristic of the thoroughness of the work of this great traveller that he actually levelled the land surface between the ancient Lop Nor depression and the Kara Koshun (the present lake bed), and has proved beyond dispute the theory of a migratory, or moving, lake. That Lou Lan was Buddhist is sufficiently attested, not only by the nature of the relics discovered on its site, but by the peculiar construction of those solid brick erections which Sven Hedin calls towers, but of which the photographs quite clearly indicate the nature. They are Buddhist topos or stupas. Thus we have another link in the long chain of Buddhist centres (temples and holy places) stretching from Western China through the deserts, past the group of towns unearthed by Stein, broken for a space by the intervening Himalayas, and then recommencing in the valleys of Gilgit, Darel and Swat, until it ended in the valley of Peshawar.

The last part of Sven Hedin's story is devoted to

records of which even Sven Hedin may be proud. To the world at large he is already known as a great geographer and an intrepid explorer. Hereafter he will be recognised as a most fascinating writer even by those who care little for geography.

T. H. H.

WATER SUPPLY AND IRRIGATION IN THE UNITED STATES.

FOR the last fourteen years very great attention has been paid by the Geological Department of the Government of the United States to the water resources of the country, and in acquiring trustworthy information as to the same.

There has recently been issued from the Government Press at Washington fifteen volumes of reports, and water supply and irrigation papers, bearing on the yield of the rivers, the various methods adopted for gauging the flow and obtaining sectional measurements, artesian wells and the flow and yield of underground water, the means adopted for storage, the use of water for the supply of towns for irrigation and for power purposes, and the pollution of rivers from sewage and other causes.¹

The greater part of these reports is taken up with records of the observations of the staff engaged in measuring the rivers in the different States and obtaining information as to water supply, which, although mainly of use to engineers in the United States, might also be interesting and instructive to those engaged in the water supply of this country.

The report No. 76 by Mr. Pressey on the flow of rivers in the vicinity of New York State is of special interest, as it deals in a comprehensive manner with the methods adopted for obtaining trustworthy information as to the yield of rivers, and gives details as to the methods adopted for obtaining the measurements necessary for the purpose.

The author of this report considers that one of the chief resources of the United States consists in its water. The prominent industrial position of several States is due largely to the abundance of available water, and the rivers with their great water power have been in the past, and

will continue to be in the future, a perpetual source of wealth. Contrary to what might have been expected, Mr. Pressey is of opinion that there never was a period in the history of the United States when the development of water power has made such strides as recently, the increase in the utilisation of water power for the period 1890-1900 being 30 per cent., or 472,361 horse power. In the State of Maine the developed power increased 60 per cent.

The rivers as water suppliers are also of inestimable value in the arid regions of the coastal States, where without an artificial supply of water there cannot be any vegetation, and where large areas have been reclaimed and made into agricultural land of great fertility by storing and distributing the water over their soils. This subject was shortly dealt with in the notice in *NATURE* of April 30, 1903, on the irrigation in the Western States of America, and of the report of the Mexico College of Agriculture in *NATURE* of August 27, 1903.

The Geological Department has for the last fourteen

¹ Copies of these reports may be obtained through Messrs. King and Son, Great Smith Street, Westminster.

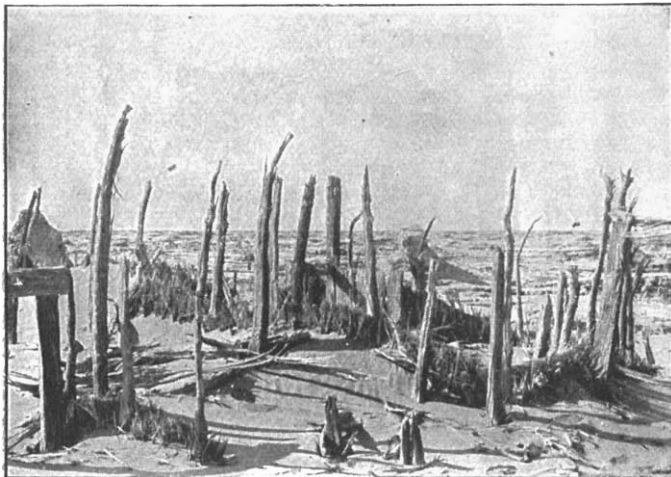


FIG. 2.—Ruined house with its doorway standing *in situ*. (From "Central Asia and Tibet.")

his gallant but unsuccessful attempt to reach Lhasa. Beyond doubt he was betrayed by the Mongol pilgrims whom he encountered early in his journey. The Lhasa authorities were fully informed, and the attempt was foredoomed to failure. None the less was it a most instructive journey. It hardly needed the evidence of the distinguished traveller to prove that Tibetans possess civilised and humane instincts. They do not necessarily ill-use a casual visitor to their country who can make himself intelligible and agreeable, but they will not admit the European within the gates of their holy city—if they can help it. We now have more material with which to construct the maps of that dreary, storm-swept, inhospitable waste which lies between the Altyn Tagh and the oasis of the Sanpo (Brahmaputra). The identification of the ancient bed of the Lop Nor and the site of Lou Lan; the elimination from our maps of the Gobi Mountains and the eastern extension of the Kurruk Range; the detailed survey of the Tarim River and the determination of the levels of the desert surface south of Lop Nor, together with the results of a vast area of geographical research on the north coast of Tibet, are

years been engaged in ascertaining the value of the rivers as water suppliers and in furnishing information upon which to base estimates of the available supply. The want of this information has frequently led to the most disastrous mistakes in the construction of hydraulic works. From ignorance of the hydrographic condition of the drainage basin of the stream, and of the region in which the stream is located, engineers have in many cases been misled by the only information available, that of the "oldest inhabitant," which may be trustworthy as to the highest level to which the water has reached in floods, but is frequently very misleading as to the low water conditions of the river. Amongst other instances recorded is one where, after an expenditure of 32,000*l.* in hydraulic works by a town where it was expected the water from a neighbouring river would be capable of developing 14,000 horse power and cause it to become a manufacturing centre, it was found that the estimate had been based upon a miscalculation as to what the river could yield to the extent of 500 per cent.

Even where statistics as to the rainfall are available, these may be very misleading so far as the yield of the drainage area is concerned unless checked by stream measurements. An instance is quoted where a calculation of the minimum yield of a river in one of the States was made independently by five experienced engineers, the quantity varying from 0.20 to 0.40 cubic foot per second per square mile.

The various forms of floats used to determine the velocity of streams are discussed in the report. For reconnaissance works surface floats have been found most convenient and approximately trustworthy. Rod floats consisting of cylindrical tubes or wooden rods 2 to 3 inches in diameter, weighted at the bottom, are considered as more trustworthy than double floats having the subsurface float connected to the upper one by a silk cord.

The current meter, on the whole, has been found to be best adapted to the general measurements made in the United States Survey. One method of using this

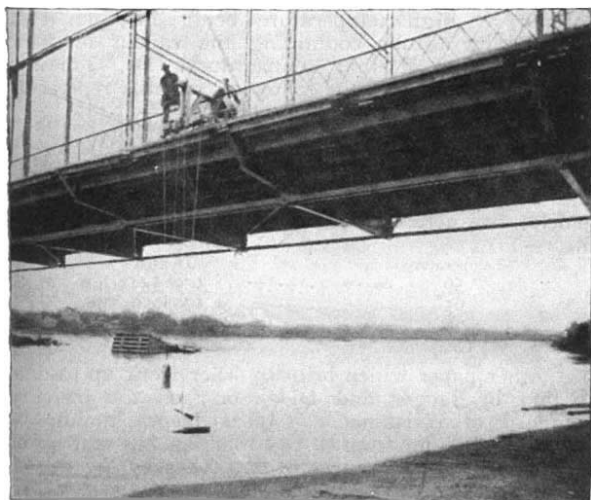


FIG. 1.—Current Meter in Use, Suspended from a Bridge.

in a wide channel is shown in the illustration (Fig. 1). In the second illustration (Fig. 2) the measurements are shown as being taken from a cable having 200 feet span placed across the stream, and supported on the right bank by timber shears 25 feet high, and on the left side anchored to a large buried oak.

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As the result of a great number of observations it has been found by the United States surveyors that the mean velocity of a stream is generally found to be at six-tenths of the depth of the water measured from the surface for wide shallow rivers, which figure should be increased to two-thirds in the case of canals and flumes or narrow natural channels. The velocity generally increases from the surface downward to

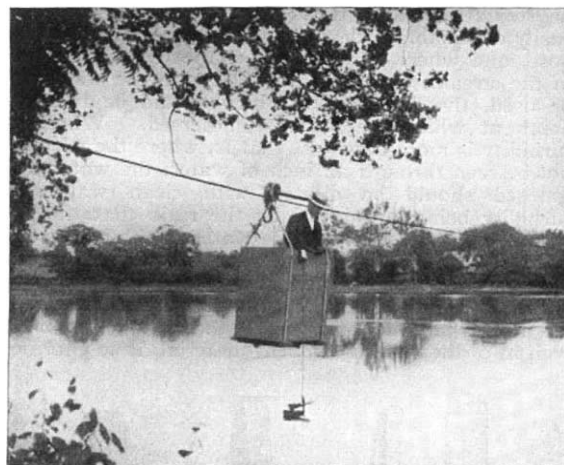


FIG. 2.—Cable and Car used to Measure Discharge of River.

about one-tenth of the depth, and then decreases to the bottom, where it reaches the minimum.

Where more than one observation was made upon the channel, the ratio between the surface and mean velocities in a stream was found, on the average of a number of experiments in different rivers, to be 0.88 of the mean of the surface velocities taken in the vertical in which the floats were run. Where only one surface float was used in the centre of the river, the coefficient was on an average found to be 0.80. The chances of error are greater where only one float is used. For shallow depths of from 3 to 8 feet the coefficient for the mean velocity varied from 0.92 to 0.82. For large deep rivers, such as the Mississippi, Humphrey's and Abbot's observations gave a coefficient of 0.98.

Measurements are also recorded of the flow of water under ice. The observations were made by cutting holes large enough to admit a current meter. In an ice-covered channel a decided drag occurs at the surface as well as at the bottom. Two points of mean velocity were found to exist in the vertical at about 0.13 and 0.73 of the depth, the maximum being at 0.35 of the depth. The best result was obtained by holding the current meter at two-thirds of the depth and applying a coefficient of 0.95 to the observed velocity at that point.

For providing uniformity in the reports of the various observers as to the quality of the water, the following standard of turbidity was used for field observations. The figure 100 was taken to represent a water containing 100 parts of silica per million, in such a state of fineness that a bright platinum wire one millimetre in diameter can just be visible when the centre of the wire is 100 millimetres below the surface of the water, the eye of the observer being 1.20 metres above the wire, the observation being made in the middle of the day, in the open air, but not in sunlight.

For taking observations a graduated rod with a platinum wire projecting from it at right angles was

used (Fig. 3), on which the graduation mark of 100 is placed on the head at a distance of 100 millimetres from the centre of the wire. When this rod is immersed in water the visibility of the projecting wire at the depth from the surface determines the degree of turbidity according to a scale given in the report. This varies from a turbidity of 7 degrees at a depth of 1095 millimetres to 100 degrees at 100 millimetres depth, 1000 degrees at 21 millimetres, and 3000 degrees at 12 millimetres. When platinum wire is not easily obtainable a clean bright pin will serve the purpose, and where observations cannot readily be made in the stream, a pail or tub filled with the water may be used, the diameter of which should be twice the depth at which the wire is immersed. Where the turbidity is more than 500, that is, where the wire cannot be seen through an inch of water, the water to be gauged should be diluted with clean water, the turbidity being multiplied by the ratio that the total volume of water bears to the water in the mixture.

In report No. 67, on the motion of underground water, by Mr. S. Slichter, it is stated that the lowest theoretical limit at which ground waters can exist is reached when the pressure in the rocks, due to the weight of the superincumbent material, is so enormous

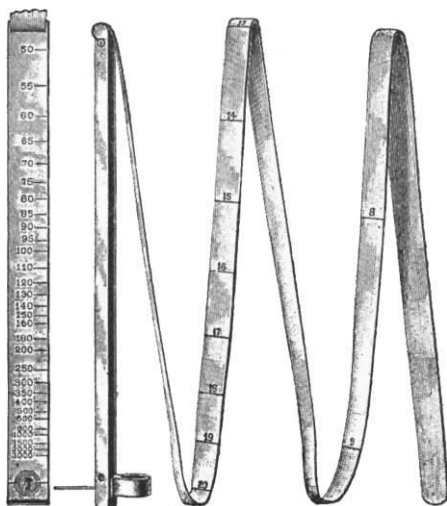


FIG. 3.—Folding Turbidity Stick.

that all cavities and pores are completely closed. This limit, it is calculated, is reached at 6 miles. The land surface of the globe covers 52,000,000, and the water surface 144,700,000 square miles. Taking the average pore space of the surface rocks occupied by water or moisture at 10 per cent., the amount of ground water is estimated at 565,000 million million cubic yards.

On this basis the underground water would be sufficient to cover the entire surface of the earth to a uniform depth of from 3000 to 3500 feet. The ground water is estimated to be about one-third the amount of the oceanic water.

The rate of movement of water through soil and rocks depends on the size of the pores of the water-bearing medium and the pressure gradient or head due to gravity. All rocks are more or less pervious to water. The porosity of quartz sand varies from 30 to 40 per cent. of the bulk. Sandstone rocks fit for building purposes contain from 5 to 25 per cent. of porosity, limestone from 1 to 13 per cent. while granite has about one-half per cent.

The water contained in porous soils and rocks possesses a slow but definite motion, and moves in an

underground current for the same reason that water moves in surface streams, flowing from a higher to a lower level.

The flow varies as the square of the size of the grains of soil, and so if the size of the soil grain be doubled, the flow of water is quadrupled.

American experience agrees with the result arrived at by French engineers that the average velocity through sands is about a mile a year.

The general trend of moving underground water under the influence of gravity is into the neighbouring streams and lakes, but the geological conditions may be such as to force the water above the surface of the ground and form springs, or it may take a general course down the thalweg and towards the sea within the porous medium itself, and so constitute an underground stream at great depth and several miles in breadth.

THE WORK OF THE REICHSANSTALT.¹

THE third volume of the *Transactions* of the Reichsanstalt was noticed in these pages some two and a half years ago. The part under review at present gives an account of the larger researches which have gone on since that date, and affords ample proof of the fact that the staff of the institution has no intention of departing from the high standard of accuracy and excellence we have learnt to expect in their work.

As in the previous volume, the first paper deals with the work of the director of the second division, Dr. Thiessen, who has continued his researches into the dilatation of solids and liquids, and has determined the dilatation of water from 50° C. to 100° C., thus completing his study from its freezing point to its boiling point.

The range from 0° C. to 40° C. had been covered by Chappuis, and the small differences between his results and those of Thiessen were noted in our former article (*NATURE*, April 25, 1901).

The method of balancing columns employed in the earlier research was used again, the water in the column at high temperature being in each case jacketed by a tube containing the vapour of some liquid boiling at that temperature. Dr. Thiessen shows that above 25° the following formula represents the results with considerable accuracy:—

$$\rho = 1 - \frac{(t - 3.98)^2}{568290} \frac{t + 343}{t + 72.75}$$

while, to continue the table given in our previous article, the actual densities found were the following:—

Temperature	Density
56°	0.985243
65°	0.980594
78°	0.973068
100°	0.958380

Another paper which brings earlier work up to date is that by Jaeger and Dieselhorst on the mercury standard of resistance. In consequence mainly of difficulties arising from electric traction, the method of comparing the resistances of the tubes by the use of the differential galvanometer has been abandoned, the Kelvin double bridge being used in its stead.

Calling *M* the mean of the resistances of four manganin coils of about one ohm resistance, we have the following series of values:—

Nov. 1893	<i>M</i> = 1.001737 ohms at 18° C.
June 1895	<i>M</i> = 37 " "
June 1897	<i>M</i> = 44 " "
March 1903	<i>M</i> = 48 " "

¹ "Wissenschaftliche Abhandlungen der Physikalisch-Technischen Reichsanstalt," vol. iv. part i.